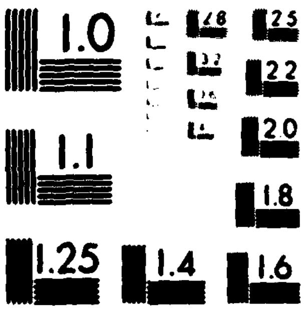
AD-A098 399 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH F/G 1/5
EFFECT OF AIRCRAFT STRUCTURAL ELEMENTS ON TIRE ADHERENCE TO AIR--ETC(U)
FEB 81 Z PYTLEWSKI
UNCLASSIFIED FTD-ID(RS)T-2020-80 NL

1 OF 1
AD A098399

END
DATE FILMED
5 81
DTIC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5

FTD-ID(RS)T-2020-80

2

FOREIGN TECHNOLOGY DIVISION

EFFECT OF AIRCRAFT STRUCTURAL ELEMENTS ON TIRE ADHERENCE TO AIRPORT PAVEMENT

by

Zhzislaw Pytlewski

Approved for public release;
distribution unlimited.

FTD-ID(RS)T-2020-80

EDITED TRANSLATION

FTD-ID(RS)T-2020-80 4 February 1981

MICROFICHE NR: FTD-81-C-000014

EFFECT OF AIRCRAFT STRUCTURAL ELEMENTS ON TIRE ADHERENCE TO AIRPORT PAVEMENT

By: Zhzislaw/Pytlewski

English pages: 13

Source: Technika Lotnicza i Astronautyczna Vol. 33, Nr. 10, 1978, pp. 19-22

Country of origin: Poland
Translated by: SCITRAN
F33657-78-D-0619
Requester: AFWAL/FIEM
Approved for public release; distribution unlimited.

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT. STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN TECHNOLOGY DIVISION.	PREPARED BY: TRANSLATION DIVISION FOREIGN TECHNOLOGY DIVISION WP-AFB, OHIO.

141

EFFECT OF AIRCRAFT STRUCTURAL ELEMENTS ON TIRE ADHERENCE TO AIRPORT PAVEMENT   Zhzislaw Pytlewski, Dr. Eng.

This article discusses means of constructing pavement of optimal roughness, dryness and cleanliness, difficulties in producing and using this type of pavement, structural changes in modern aircraft associated with a reduction of speed when moving on aircraft pavement, and the concomitant increase in tire adherence.

The adherence of tires to airport pavement when aircraft are landing or taking off is affected not only by improvements in the abrasive pavement layer, bettering its adherence, the state of the airport pavement, but also by structural elements of the aircraft and its slowest landing or takeoff speed (up to 200 km/h).

On the basis of foreign literature we can mention the following ways of improving the abrasive pavement layer of airports to improve tire adherence:

-- Transverse grooving of the pavement in connection with a drainage system (for roughness and rapid draining);

-- Rough coatings for porous pavement of special construction with high filtration and drainage capability (in the vertical direction), or with a suitably installed drainage system (in the horizontal direction), guaranteeing rapid drying of the pavement in times of use;

-- Coatings or pavement in the form of a rough layer with increased adherence and maintenance in comparison to the cement concrete or asphalt concrete pavement used up to now. These features can be achieved by using improved binders, aggregate and additives (coating reinforcement), such as fiberglass, asbestos fiber, mineral fiber, wire, etc. (this method is also used partially in connection with a drainage system, in our country, with respect to improved binders in cement concrete pavement);

-- Shellgrip or an adhesive porous coating (of great roughness) with rough aggregate 16/25 mm in diameter, with an additive of natural resin

(shellac) or artificial resin (epoxy) in connection with a special drainage system; fibers, wires, etc. are used for mechanical reinforcement of relatively thin coatings.

The virtue of the thin coatings mentioned, and of abrasive layers, is their great roughness and the maintenance of the pavement in a condition as dry and clean as possible. Such a pavement has the greatest coefficient of adhesion with aircraft wheels.

These rough, clean and dry coatings, which theoretically (under laboratoty conditions) proved to be most technically suitable for airport pavement, proved in practice to be difficult and expensive to install, as well as difficult to use. The drainage system was easily silted up by mud, which required the pavement to be frequently rinsed and washed.

These difficulties in designing, installing and using airport pavements made it necessary to introduce simultaneous changes in the structural elements of aircraft in order to improve the adherence of tires to the pavement. Adhesion improvement was gained by using improvement in the structure and system of aircraft undercarriages (i.e., struts, shock absorbers and tires).

Effect of Structural Changes in Modern Aircraft on Reducing Speed of Movement on Airport Pavement

It has been determined experimentally that the magnitude of the coefficient of adherence of aircraft tires depends to a considerable degree on the speed of its movement on airport pavement; the less the velocity, the greater the coefficient of adherence and in turn the greater the flight safety.

In the summer on a wet airport pavement, the coefficient of adherence at a braking speed of 50 to 200 km/h has an average value of 0.58-0.46, i.e., a drop in the coefficient of adherence is observed with speed at an average of 0.01 per 10 km/h. Above 200 km/h this drop amounts to as much as 0.02 per

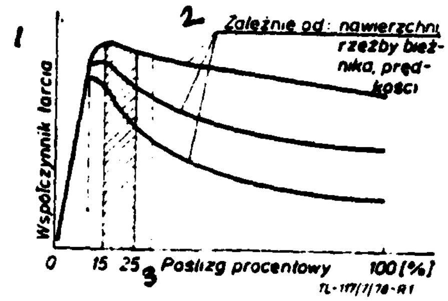


Figure 1. Effect of Tire Skidding on Coefficient of Friction (Dependent on Pavement, Tread Pattern and Speed).

Key: 1-Coefficient of friction, 2-Dependent on: pavement, tread pattern, speed, 3-Skid percentage

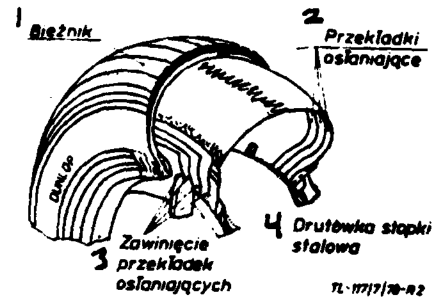


Figure 2. Construction of Ordinary Aircraft Tire with Cruciform Spacers.

Key: 1-Tread, 2-Protective spacers, 3-Bundle of protective spacers, 4-Steel band of flange

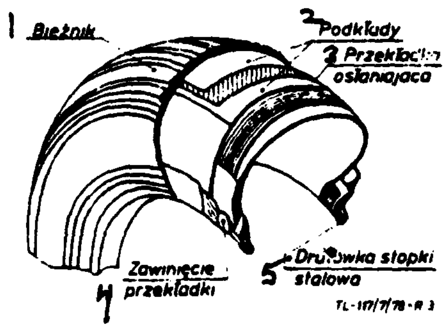


Figure 3. Construction of Special Aircraft Tire with Radial Spacer.

Key: 1-Tread, 2-Backing, 3-Protective spacer, 4-Bundle of spacers, 5-Steel band of flange.

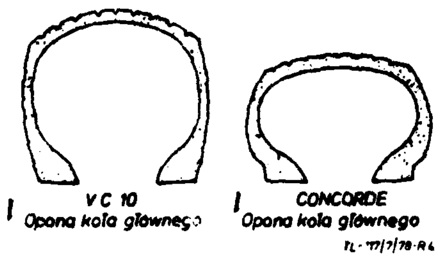


Figure 4. Shapes of Modern Aircraft Tires (for VC-10 and Concorde Aircraft) Showing the Oblateness of Their Profile.

Key: 1-Tire of main wheel

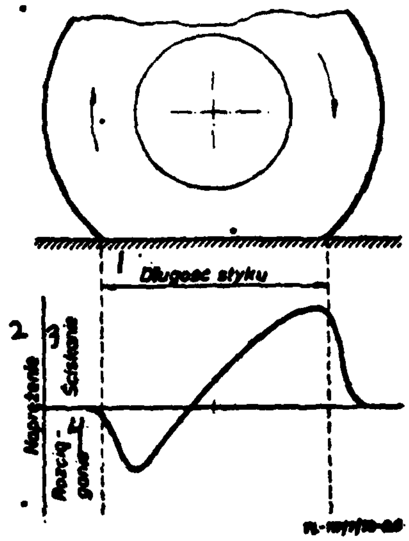


Figure 5. Look of a Tire in Contact. Variable stresses appear in lengthwise contact: stretching and compression.

Key: 1-Contact length, 2-Stress, 3-Compression, 4-Stretching

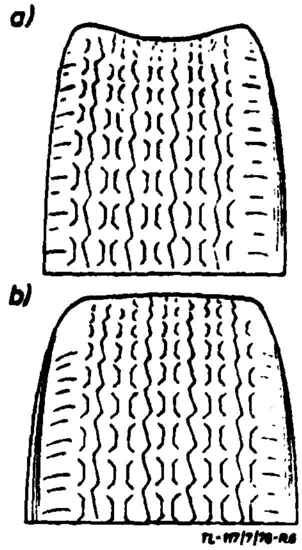


Figure 6. Inclination of Tire Causing Minimal Pressure in the Center of the Surface Adhesion to the Pavement and Maximal on its Rims: a) standard aircraft tire inclined (excessive load); b) aircraft tire working correctly (normal load)

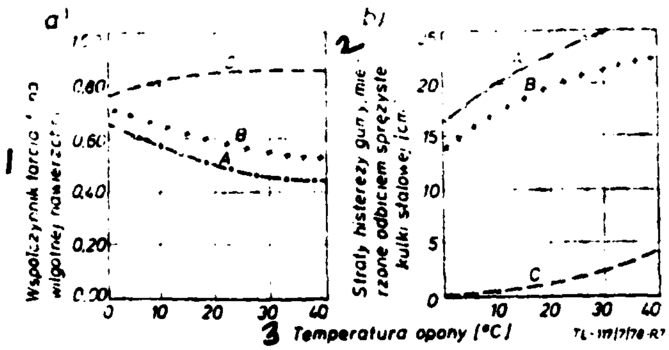


Figure 7. a) effect of hysteresis of tires on coefficient of friction (dependent on type of tire rubber and temperature); b) elasticity of tire rubber; losses of rubber hysteresis, measured by the rebound of a steel ball (dependent on temperature for three types, rubber A, B, C of varying elasticity, Shore's hardness) according to English research; A - elastic rubber, B - rubber of average elasticity, C - solid rubber.

Key: 1-Coefficient of friction on wet pavement, 2-Losses in rubber hysteresis measured by the rebound of an elastic steel ball (cm), 3-Tire temperature.

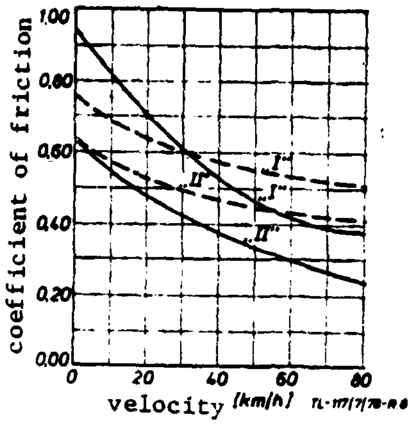


Figure 8. Dependence of Coefficient of Friction on Type and Degree of Configuration of Tire Tread. Solid line, tire with smooth tread; broken line, tire with sculptured tread; "I" - "I" dry pavement; "II" - "II" wet pavement.

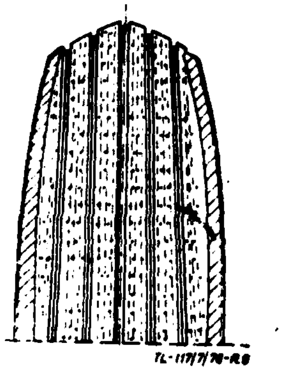


Figure 9. Aircraft Tire Resistant to Skidding in Water, Dunlop Product.

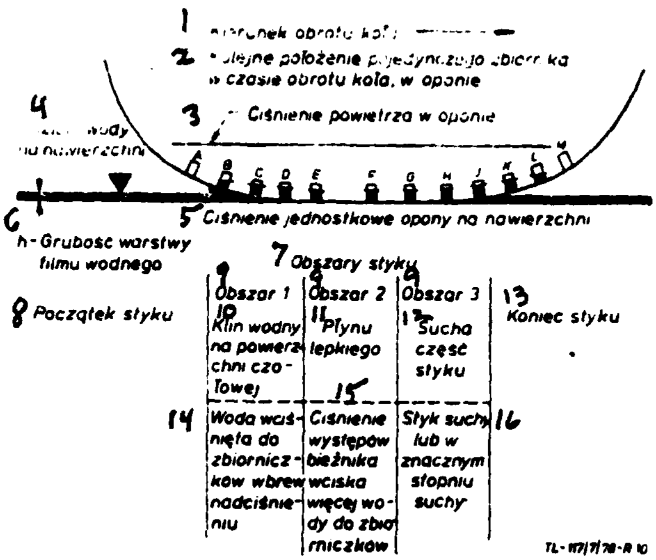


Figure 10. Work of Aircraft Tire on Wet Pavement in Three Stretches with Tread Touching.

Key: 1-Direction of wheel revolution, 2-Successive position of individual tank while wheel is turning, in tire, 3-Air pressure in tire, 4-Water level on pavement, 5-Individual pressure of tire on pavement, 6-Depth of water film layer, 7-Contact areas, 8-Beginning of contact, 9-Area, 10-Band of water on leading surface, 11-Viscous fluid, 12-Dried part of contact, 13-End of contact, 14-Water forced into receptacle despite overpressure, 15-Pressure of tread projections forces more water into receptacles, 16-Dry or quite dry contact.

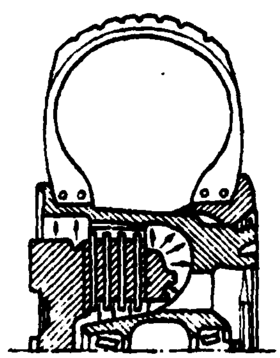


Figure 11. Heat Conduction from Braking System Through Wheel to Tire Rim Bundle.

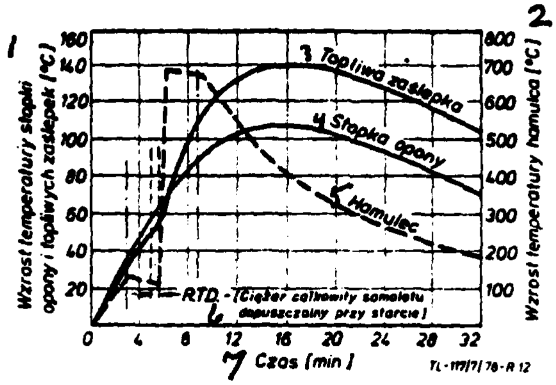


Figure 12. Heat Concentration in Flanges for Aircraft which does not Leave the Ground.

Key: 1-Increase in temperature of tire flange and fusible plugs (°C), 2-Increase in brake temperature, 3-Fusible plug, 4-Tire flange, 5-Brake, 6-RTO (total weight of aircraft permissible at takeoff), 7-Time (min)

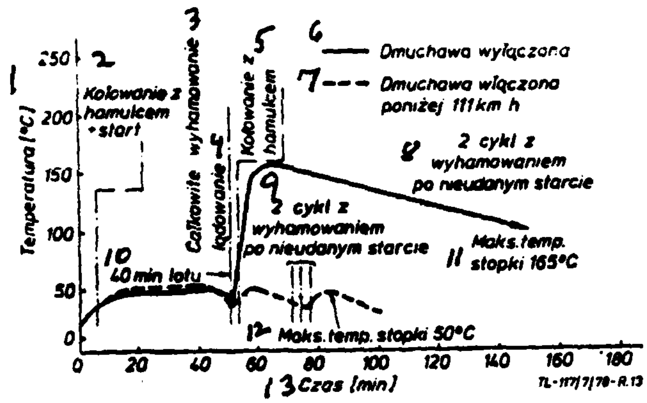


Figure 13. Effect of Blower Cooling on Temperature of Tire Flange. Solid line, blower disconnected; broken line, blower connected above 111 km/h.

Key: 1-Temperature (°C), 2-Rolling with brake at start, 3-Total braking, 4-Landing, 5-Rolling with brake, 6-Blower disconnected, 7-Blower connected above 111 km/h, 8-2 cycles with braking after unsuccessful takeoff, 9-2 cycles with braking after unsuccessful takeoff, 10-40 minute flight, 11-Maximum flange temperature 165°C, 12-Maximum flange temperature 50°C, 13-Time (min)

10 km, while at a speed of 350 km/h the coefficient of adherence drops to a value of 0.16. Keeping in mind that the coefficient of adherence should not be less than 0.40 for safe movement, it is easy to calculate that the maximal critical speed of movement on a wet airport pavement made of cement concrete should not be greater than 230 km/h.

The situation is considerably worse on wet pavement made of asphalt concrete, where a mean drop in the coefficient of adherence from 0.015 per 10 km/h to 0.02 per 10 km/h is observed in the speed range of 50-200 km/h. On this kind of slippery pavement made of asphalt concrete, the coefficient of adherence on the average comes to 0.50-0.30 for a speed of 50 to 200 km/h, and the maximal critical speed of movement is only 100-120 km/h.

During the summer things are even more slippery on dirty pavement covered with mud (soil washed from shoulder), while things become even much worse in the autumn-winter-spring period with snowfalls, glazed frost or icing. At this time the coefficient of adherence can reach its minimal values of 0.05-0.08, threatening safety at any speed as long as the mud, snow or ice have not been removed.

In order to reduce the speed of the landing and the landing run of aircraft, particularly during the autumn-winter-spring period, recourse is most often found in such equipment as:

-- Braking parachutes,

-- Braking flaps, and

-- Blowing on the flaps below the wings in order to increase wing efficiency at large angles of attack,

-- Thrust spoilers or reversers in jet engines,

-- Additional braking engines, etc.

In addition, but rather exceptionally, braking rockets and skids are used. This equipment reduces the landing speed of jet aircraft to approximately 200-350 km/h, depending on the type of airport pavement, and thus to values at which it is possible to begin braking by using the brakes.

Changes in Undercarriage Structure

An increase in the adherence of aircraft tires to airport pavement can be achieved through changes in the undercarriage structure, based on improvements in the legs, shock absorber and tires (tires with tubes), namely:

-- Increasing the number of wheels on each leg,

-- Increasing the spacing of these wheels in the lateral and longitudinal directions,

-- Increasing shock absorber quality,

-- Changes in the geometric shape of the undercarriage system,

-- Changing the load on wheels, the unit pressure in the tires, and other improvements in tires, and

-- Using equipment to deploy the undercarriage wheels before landing.

Some changes in the undercarriage structure are also the result of the development of aircraft braking systems with a simultaneous need for increasing their weight. This leads to a tendency to make the tire profile oblate (wide tires) and to reduce the diameter of the wheel (also in view of decreasing the aircraft undercarriage locking space), and increasing the diameter and width of the braking systems. Other changes in undercarriage structure stem from the need to use blocking controls and wheel skid controls with special electrical devices for automatic control of the work of the brakes.

These electronic devices for intermittent activation of the brakes function in a forced skid of braked wheels in the area of 15-25%, which produces an increase in the coefficient of adherence and an improvement in

the braking effect on dry pavement by 20-30% (compared to blocked wheels at 100% skid). An increase in braking effect is also observed on wet pavement.

Cooling devices and also frictional elements made of beryllium are used in some braking structures. The great capacity to absorb and conduct heat increases the braking effect.

Improvements in ıre Structure

Improvements in tire structure are most often based on the gradual introduction of radial tires (Figure 3) to replace the regular tires used up to now with cruciform spacers in the cord (Figure 2).

Trends to make the tire profile oblate, as illustrated in Figure 4, are also observed.

The initial proportion of conve tional aircraft tire height and their radial proportions to their width, which were 1:1, are being changed and appearing from 0.6-1.

Radial tires have many advantages with respect to reinforcement (longitudinal steel cord and transverse radial reinforcement with low side walls) and show greater adherence to the pavement than conventional tires in both longitudinal and transverse directions; they are also less subject to the unfavorable phenomenon of tire inclination (Figures 5 and 6).

Radial tires also exhibit greater resistance to temperature and to fatigue, which improves their service life in comparison to normal tires. However, in addition to the above-mentioned benefits, they also have a number of defects which cause difficulties in applying them to aircraft. However, experimental work to improve the structure of these tires is still in progress.

Great possibilities for improving the coefficient of adherence of tires to pavement by 30-50% exist, thanks to the phenomenon of hysteresis or lag

of tire elements behind the movement of the wheel. It should also definitely be kept in mind that, although the effect of hysteresis on adherence is considerable, it is associated with a great increase in temperature. A number of investigations are proceeding in this area (in England, for example) on tires with different grades of rubber (Figures 7A, 7B) on wet and dry pavement.

In contradistinction to automobile tires, aircraft tires are used at present at even critical speeds and must have low hysteresis or great resistance to temperature.

Improvements are also used in the sculpturing of tire treads, making it possible to increase the coefficient of adherence on wet pavement by eliminating water skid. Figure 8 shows the dependence of the coefficient of adherence or friction of tires with a smooth and sculptured tread on the pavement (in the area of low speeds up to 80 km/h). It can be seen from the figure that a tire without treads has better adherence on dry pavement at low speeds (up to 60 km/h) than tires with treads.

At the present time in England, among other places, Dunlop is producing special tires resistant to water skid, called Aquagrip. Figure 9 shows an aircraft tire resistant to water skid, and Figure 10 shows how this tire works on a wet pavement with the speed of water runoff being a function of pressure, the thickness of the water film and the water viscosity. These tires differ from normally used tires in the width and depth of the grooves and by a very large number of small openings (holes), which serve to drain and vent the tires while they are working. At the same time these openings counteract the heating of the tires, which increases their hysteresis. Various structural solutions are also used to reduce tire temperature, i.e., cooling by blower (Figure 13) in the case of heavy military and transport aircraft. Figures 11, 12 and 13 illustrate the action of temperature on

tires when aircraft are taking off and landing. The greatest tire temperature on takeoff and landing of an aircraft occurs in the upper part of the tire at the rims, transmitted from the braking system (as can be seen in Figure 11).

Conclusions

The adherence of aircraft tires to airport pavement can be increased by improvements systematically introduced into airport pavement and structural elements of aircraft.

The greatest effects of increasing adherence can be achieved by reducing takeoff and landing aircraft speed, at the same time achieving optimal improvement in safety conditions.

END

DATE
FILMED
5 81

DTIC